echnical Paper 141

DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, SECRETARY
BUREAU OF MINES
VAN. H. MANNING, DIRECTOR

LABORATORY DETERMINATION OF THE EXPLOSIBILITY OF COAL DUST AND AIR MIXTURES

BY

J. K. CLEMENT AND J. N. LAWRENCE

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

Generated on 2024-09-28 16:13 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

The Bureau of Mines, in carrying out one of the provisions of its organic act—to disseminate information concerning investigations made—prints a limited free edition of each of its publications.

When this edition is exhausted copies may be obtained at cost price only through the Superintendent of Documents, Government Printing Office, Washington, D. C.

The Superintendent of Documents *is not an official of the Bureau of Mines.* His is an entirely separate office, and he should be addressed:

SUPERINTENDENT OF DOCUMENTS,
Government Printing Office,
Washington, D. C.

The general law under which publications are distributed prohibits the giving of more than one copy of a publication to one person. The price of this publication is 10 cents.

First edition. April, 1917.

Generated on 2024-09-28 16:16 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

CONTENTS.

	Page.
Introduction	5
Acknowledgments	6
Apparatus	6
Description	6
Method of operation	8
Tests of typical coals at various temperatures	9
Standardization of laboratory method	11
Inflammability of mixtures of coal dust and shale dust	14
Inflammability of dust in air containing small amounts of natural gas	19
Results of inflammability tests of various coal dusts	23
Summary	31
Publications on coal mining	32

TABLES.

TABLE 1.	Inflammability of dust prepared from face samples	26
2.	Inflammability of road and rib dusts	29

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

ILLUSTRATIONS.

		Page.
PLATE I.	Inflammability apparatus	6
FIGURE 1.	Sketch of inflammability apparatus	7
2.	Relation between pressure developed in inflammability apparatus and temperature of igniter for 5 typical coals	10
3.	Relation between inflammability and composition of mixtures of experimental mine coal dust and shale dust	13
4.	Relation between inflammability and composition of Lucerne mine coal-dust and shale-dust mixtures	15
5.	Relation between inflammability and composition of Layland mine coal-dust and shale-dust mixtures	16
6.	Relation between inflammability and composition of Eccles No. 3 mine coal-dust and shale-dust mixtures	16
7.	Relation between inflammability and composition of Maryland mine coal-dust and shale-dust mixtures	17
8.	Relation between inflammability and composition of ignition limit mixtures	18
9.	Relation between inflammability and composition of propagation limit mixtures	19
10.	Effect of presence of combustible gas on inflammability of Lykens Valley, Pa., anthracite dust	21
11.	Effect of presence of combustible gas on inflammability of anthracite dust from Bankhead mine, British Columbia	21
12.	Effect of presence of natural gas on the inflammability of mixtures of experimental mine coal dust and shale dust	22
13.	Effect of presence of natural gas on inflammability of a mixture consisting of Pittsburgh coal dust, 25 per cent, and shale dust, 75 per cent	23
14.	Effect of presence of natural gas on inflammability of mixtures of Eccles No. 3 mine coal dust and shale dust	24
15.	Effect of presence of natural gas on inflammability of a mixture consisting of Eccles No. 3 mine coal dust, 40 per cent, and shale dust, 60 per cent	25

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

LABORATORY DETERMINATION OF THE EXPLOSIBILITY OF COAL DUST AND AIR MIXTURES.

By J. K. Clement and J. N. Lawrence.

INTRODUCTION.

Two previous publications of the Bureau of Mines have been devoted to the laboratory investigations of the inflammability of coal dust.[a] In both of these the value of a reliable laboratory method for measuring the inflammability of dusts was pointed out.

The term "inflammability" as used in this report may be defined as the ease with which a flame can be produced in a cloud of dust that will travel beyond the influence of the igniting agent.

Various investigators have devised a number of laboratory methods for determining relative inflammability,[b] but with most of the methods previously described it has not been possible to distinguish between dusts that may give rise to explosions in the mine and those that will not. Such a differentiation of dusts obviously depends on the availability of data concerning the behavior of dusts under actual mining conditions as well as on the sensitiveness of the laboratory method. Data of this nature have been available only within a few years.

During the course of the investigations at the experimental mine of the Bureau of Mines it was found that dusts of too low inflammability to be ignited in the laboratory apparatus previously used by the bureau, and described in Bulletins 50 and 102, were nevertheless capable of propagating violent explosions in the mine. Consequently it became necessary to increase the sensitiveness of the laboratory method.

The laboratory method described in this paper is capable of measuring the inflammability of the least inflammable dusts that will propagate an explosion in the mine. A relation has been established between the results of tests on a large scale at the experimental mine

[a] Frazer, J. C. W., Hoffman, E. J., and Scholl, L. A., jr., A laboratory study of the inflammability of coal dust: Bull. 50, Bureau of Mines, 1913, 60 pp.; Clement, J. K., and Scholl, L. A., jr., The inflammability of Illinois coal dusts: Bull. 102, Bureau of Mines, 1916, 74 pp.

[b] See Rice, G. S., and others, The explosibility of coal dust: Bull. 20, Bureau of Mines, 1911, 204 pp.

Generated on 2024-09-28 16:13 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

and the results of laboratory tests, so that it is now possible to determine from laboratory tests alone whether or not a given dust may give rise to or propagate explosions.

Normal air has been used in previous laboratory experiments with dusts. Recent work at the experimental mine has shown that dusts which in normal mine air are not capable of propagating an explosion may, in the presence of a small percentage of natural gas, readily propagate an explosion. The laboratory method has therefore been so modified that dusts may be tested in the presence of various percentages of combustible gas; and the effect of small amounts of combustible gas on the inflammability of dust has been investigated.

The igniting agent may be the flame from a blown-out shot, the flame of an oil lamp, or the surface of an incandescent solid body. In the apparatus used to measure inflammability in the experiments herein described a heated platinum tube serves as the igniter. The igniter is placed at the center of a spherical vessel and a cloud of dust is blown past it through an opening in the bottom of the vessel. The pressure produced by the combustion of the dust is taken as a measure of its inflammability.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to G. S. Rice, chief mining engineer of the Bureau of Mines, for his general interest in the work and for valuable suggestions concerning it; to A. C. Fieldner, chemist, under whose direction the dust samples were prepared and analyzed; and to W. T. Hausstein, foreman instrument maker, for assistance in the design and the construction of the apparatus employed.

APPARATUS.

DESCRIPTION.

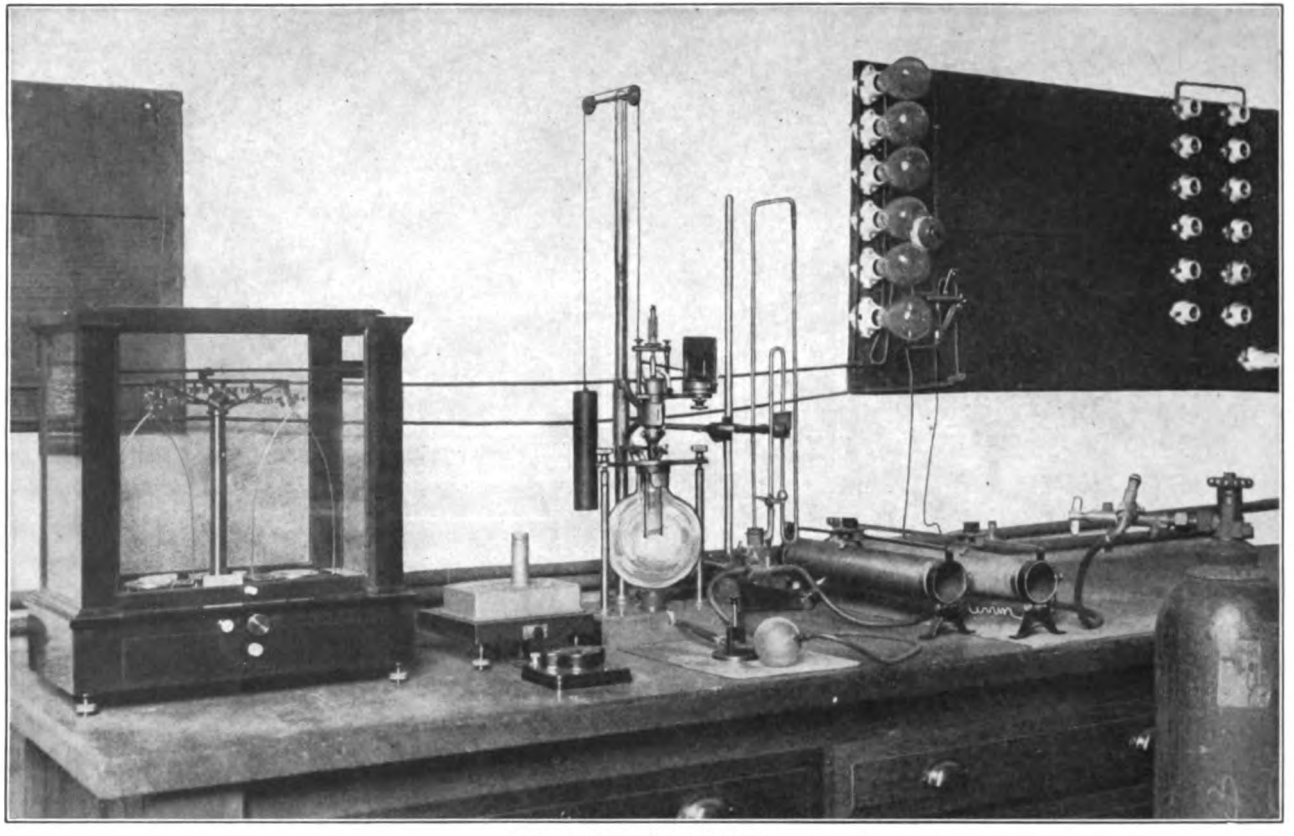
The apparatus is shown in Plate 1 and figure 1. The essential features are the explosion globe *a*, the igniting tube *b*, the pressure-recording device *c*, the lifting device *d*, and auxiliary devices for measuring the temperature of the igniting tube and for throwing the dust into suspension.

The explosion globe, capacity 1,400 c. c., is fitted with tubulures at its top and bottom. The lower tubulure is provided with a rubber gasket, and the upper tubulure presses against a rubber gasket cemented to the head of the apparatus. The joints at the top and bottom of the globe are made gas-tight by screwing down the thumb nuts *e*.

The glass dust injector *f* is the receptacle for the coal dust and is provided with a cap of 14-mesh copper gauze, not shown in the figure. The dust is raised in a cloud by a puff of oxygen.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:23 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google



INFLAMMABILITY APPARATUS.

Digitized by Google
Original from PRINCETON UNIVERSITY

The oxygen is drawn from a steel cylinder and the puff is controlled by means of the manometer g, the reservoir h, and the releasing device i. The rapidity with which the oxygen forces the dust out of the injection funnel is regulated by a capillary tube, 2 mm. in diameter and 6 cm. long, inserted between the releasing device and the injection funnel.

The igniting tube consists of a hardened "lavite" tube on which is wound a heating coil of 0.23 mm. platinum wire, 40 turns to the

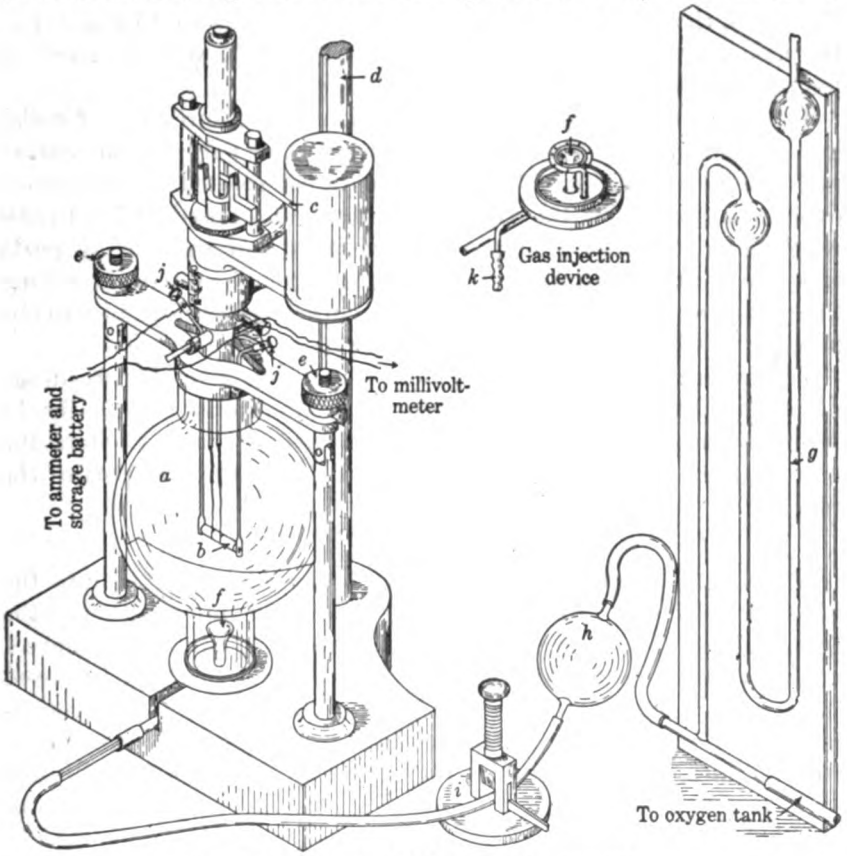


FIGURE 1.—Sketch of inflammability apparatus.

inch, inclosed in a platinum tube made of 0.1 mm. sheet platinum. On the surface of the "lavite" tube is cut a suitable spiral groove in which the platinum wire is wound. The wire is insulated from the platinum tube by a layer of alundum cement which is baked on. The igniting tube is held in place by platinum leads of 0.4 mm diameter which are fused to the ends of the heating coil and secured in the binding posts at the lower extremities of the steel leads j.

The temperature of the platinum tube is measured by a platinum and platinum-rhodium thermocouple and a Siemens & Halske milli-

Generated on 2024-09-28 16:16 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

voltmeter. The ends of the platinum and platinum-rhodium wires, instead of being fused together in the usual manner to form the hot junction, are attached separately to the platinum tube; the platinum-rhodium wire at the middle of the tube and on the front side; the platinum wire about 3 mm. to one side of the platinum-rhodium wire. The point of contact of the platinum-rhodium wire with the platinum tube is therefore the hot junction of the couple. To reduce to a minimum the loss of heat from the tube by conduction along the wires, the ends are drawn down to a diameter of 0.15 mm. The thermocouple and millivoltmeter were calibrated, and the error of temperature measurement is less than 10° C.

The pressure developed by the explosions is measured by a Crosby gas and steam engine indicator. Inasmuch as only the maximum pressure is desired, the drum is ordinarily not rotated. Preliminary experiments in which the drum was rotated at a speed of 140 to 200 revolutions per minute showed that the inertia of the moving parts was not great enough to prevent the gage from correctly indicating the pressures developed. The pressure curve rose rapidly to a maximum from which it dropped very slowly.

For experiments in an atmosphere containing a small percentage of combustible gas a base plate, provided with a brass tube *k* (fig. 1) for introducing the combustible gas, is used. The gas enters the bulb through eight small holes in the wall of the circular port of the tube.

METHOD OF OPERATION.

A weighed quantity of the dust to be tested is poured into the glass funnel *f* (fig. 1) and by tapping is brought into position in the funnel stem. The apparatus is then connected as shown in figure 1 and a current of two amperes taken from a storage battery is passed through the heating coil for one minute, after which the current is increased so as to obtain the desired temperature and continued for four minutes. The pressure of the oxygen in reservoir *h* is adjusted to 15 or 20 cm. of mercury, according to the quantity of dust to be used.

At the end of the five-minute period the vent in the head at the top of the explosion flask is closed with a spring clip, the rubber tube leading into the oxygen reservoir is closed immediately at the entrance of the reservoir by means of a pinch cock, and then the piston of the releasing device is allowed to spring up. A touch on the lever at the right of the piston permits this action. The dust is injected into the explosion globe and is ignited by contact with the igniting element.

In regular work two explosion globes are employed. While one is used in a test, the other is blown out with a blast of air, which renews the atmosphere in the globe and cools the globe itself.

Generated on 2024-09-28 16:17 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

The pressure shown by the Crosby indicator is corrected for the increase due to the injected oxygen by deducting the pressure observed when no dust is used. The pressure reported is always the average of at least three determinations.

The pressures developed vary from a few tenths of a pound with anthracite or with dust very high in ash to 20 pounds with subbituminous coals. Coals of the Pocahontas type give pressures varying from 6 to 10 pounds, and typical Pennsylvania bituminous coals, such as those of the Pittsburgh bed, give pressures of 11 to 15 pounds.

The maximum difference between individual determinations on the same sample of dust is usually not over 2 pounds for dusts that develop 10 to 15 pounds pressure. Averages determined by different observers or by the same observer on different days agree ordinarily within 0.5 pound. The greater the deviation between individual observations the larger the number of determinations required.

Usually the quantity of dust used in an experiment is 100 mg. For dusts of low inflammability the amount is 300 mg. With the former quantity of dust the pressure of the oxygen used to eject the dust is 15 cm. and with the latter quantity 20 cm. of mercury. Unless otherwise stated, the tests recorded are made with 200-mesh air-dried samples.

When tests are to be made with a small percentage of combustible gas present in the bulb, the igniting element is raised above the top of the bulb and heated to the proper temperature. The top tubulure is closed and a measured volume of gas introduced into the bulb. At the close of the five-minute interval the head of the apparatus is quickly lowered and fixed in position and the dust injected into the globe. As this operation consumes not over five seconds, the composition of the gas is not appreciably changed before the dust is injected.

TESTS OF TYPICAL COALS AT VARIOUS TEMPERATURES.

The results obtained with five typical coals are shown in figure 2; the proximate analyses of the coals are given in the following table:

Proximate analyses of air-dried samples.

Sample No.	State.	Type.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Utah	Subbituminous	2.13	44.10	47.52	6.25
2	North Dakota	Lignite	8.60	41.03	39.54	10.83
3	Pennsylvania	Bituminous	2.13	32.75	59.19	5.93
4	Alabama	do	.57	26.33	64.25	8.85
5	West Virginia	Semibituminous	.48	16.75	78.04	4.73

In figure 2 the pressure developed in the inflammability apparatus is plotted as ordinate and the temperature of the igniter as abscissa.

Generated on 2024-09-28 16:16 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

The lowest temperature at which pressure was developed was 750° C. with the lignite, and 925° to 975° C. with the bituminous and semi-bituminous coals. The curves rise rapidly for the first 100° rise in temperature and then become gradually flatter, reaching a nearly constant maximum pressure at 1,200° C.

One object in studying the influence of temperature on the pressure developed by the dusts was to ascertain the temperature best

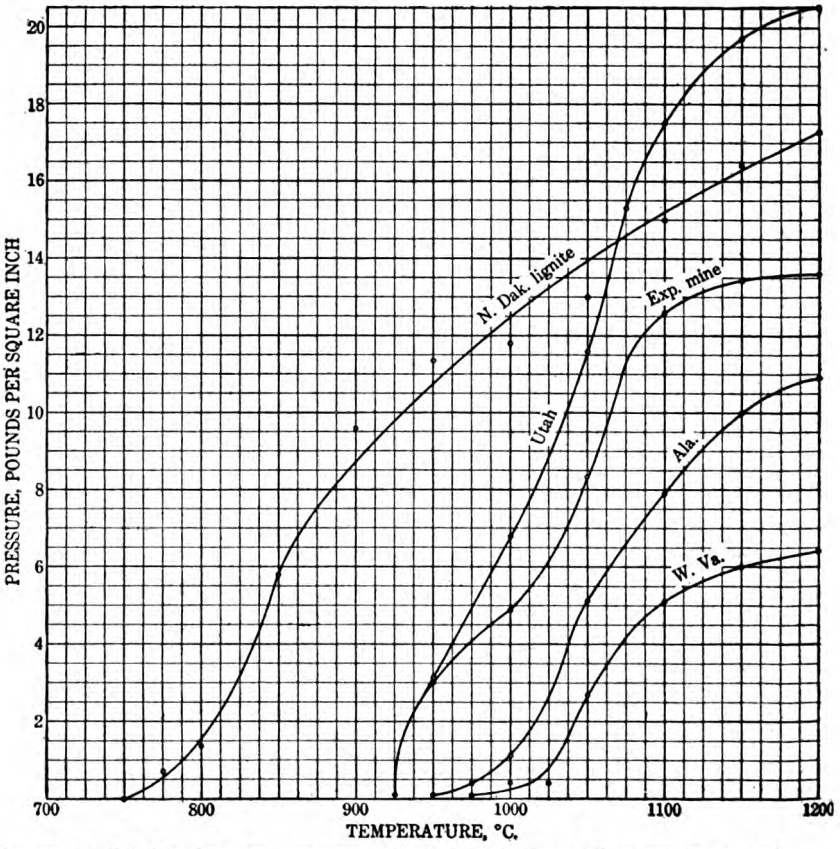


FIGURE 2.—Relation between pressure developed in inflammability apparatus and temperature of igniter, for five typical coals.

suited for inflammability experiments. It is advisable to select a temperature in the region in which the curves are flattest, so that a small variation in the temperature of the igniter, such as might be caused by an error in temperature measurement, will cause a minimum variation in the pressure developed. It was not considered desirable to work at temperatures above 1,200° C. because of the short life of the platinum coils at such temperatures. At 1,200° C. however, the slope of the curves is so small that a variation of

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

10° or even 20° causes no material variation in the pressure. This temperature was adopted as the working temperature.

It is evident from figure 2 that except for the lignite dust, at temperatures above 1,000° C. the pressure developed by the several coal dusts are in the same order as those at 1,200° C., and the relative inflammability as measured by the ratio of the pressure would not differ greatly from the values at 1,200°. The inflammability of the lignite dust as determined by the pressure developed at 1,200° C. lies between that of Pennsylvania bituminous dust and Utah subbituminous dust. However, in the laboratory apparatus the lignite dust ignites at a much lower temperature than the other dusts and, at temperatures below 1,050° C., develops much greater pressures. Conclusions as to the inflammability of lignite dusts should not be based on laboratory tests alone until information is obtained as to the behavior of the dusts in the mine.

For all the dusts that have been tested at the experimental mine, the order of inflammability found in the mine agrees with that found in the laboratory. In fact, there is a definite relation between the inflammability determined by the pressure developed in the laboratory apparatus and the degree of inflammability determined at the mine.

As regards the question of the danger of dust explosions in lignite mines the reader should remember that whereas the laboratory tests are habitually made with air-dried samples, nearly all lignites in the United States carry a high percentage of moisture when mined. The sample of lignite from North Dakota had a moisture content of 38.52 per cent as received; this was reduced to 8.60 per cent by air drying.

A Montana lignite tested in this laboratory carried 41.3 per cent of moisture when received and 10.6 per cent when air dried. The inflammability of 200-mesh samples of both "as received" and "air-dried" lignite was determined in the usual manner; 100 mg. of the "air-dried" sample gave a pressure of 15.4 pounds per square inch, whereas 300 mg. of the "as-received" sample gave only 0.9 pounds per square inch.

Because lignites have a high moisture content the danger of dust explosions in lignite mines is much less than would be indicated by a laboratory test of an "air-dried" sample.

STANDARDIZATION OF LABORATORY METHOD.

In order to predict from laboratory tests the behavior of dusts in the mine a relation must first be established between the laboratory results and those obtained under the conditions of actual mining.

If a series of dusts varying in inflammability from the least to the most inflammable is obtained, and the several members of the series are tested under actual mining conditions, as well as in the laboratory,

Generated on 2024-09-28 16:19 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

the desired relation will be established. Such a series of dusts has been prepared by mixing coal dust from the experimental mine with shale dust in various proportions, and these mixtures have been tested in the laboratory and in the experimental mine. Laboratory tests have been made by the two methods previously described, that is, by using both 100 mg. and 300 mg. of dust. The results are shown by the curve in figure 3 (p. 13), the composition of the mixtures being plotted as abscissas and the inflammability as ordinates. With this curve the inflammability of any dust that has been tested in the laboratory may be expressed in terms of the equivalent mixture of dust from the exerimental mine and shale dust. For example, a dust that develops a pressure of 8 pounds per square inch (with 100 mg.) in the laboratory apparatus is equal in inflammability to a mixture containing 56 per cent of the mine dust and 44 per cent of shale dust. Tests at the experimental mine have shown that such a mixture may be readily ignited by the flame of a blown-out shot.

Dusts may be conveniently classified as follows:

1. Dusts that, when suspended in air, may be ignited by a flame and give rise to an explosion.

2. Dusts that, when suspended in air, can not be ignited by a blown-out shot, or burning gas, or by an electric arc, but may propogate an explosion set up in a cloud of more inflammable dust or in an explosive gas mixture.

3. Dusts that will not propagate an explosion.

It is especially important to be able to ascertain by laboratory tests to which of these groups any given dust belongs; that is, to determine whether the dust is capable of propagating an explosion or of being ignited by a flame.

In the work at the experimental mine the term "ignition limit" is used to designate the highest percentage of shale dust with which a given coal dust can be mixed and yet be ignited by the flame of a blown-out shot of black powder and give rise to an explosion. The "propagation limit" of a dust is the highest percentage of shale dust with which it can be mixed and still be capable of propagating an explosion. In the above classification the "ignition limit" mixture falls on the boundary between classes 1 and 2; and the "propagation limit" on that between classes 2 and 3. The ignition and propagation limits of a number of typical dusts have been determined at the experimental mine. The ignition limit of the experimental mine coal dust, for example, has been found to be 59 per cent[a] shale, and the propagation limit 73 per cent[a] shale.

In Figure 3 the horizontal line A is drawn to intersect the curve for 100 mg. at the point corresponding to a mixture containing 59

[a] Limits not determined experimentally closer than 5 per cent and in most cases 10 per cent.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

per cent of shale dust, and shows the pressure, 3.5 pounds, developed by 100 mg. of the ignition-limit mixture. Similarly, the line *C* represents the pressure developed by 300 mg. of the same dust mixture, and lines *B* and *D* represent the pressures developed by 100 mg. and 300 mg., respectively, of the propagation-limit mixture.

Dusts that in tests with 100 mg. give pressures falling above the line *A* will be ignited by flame and give rise to an explosion. Dusts giving pressures falling between the lines *A* and *B* will not be ignited by a flame, electric arc, or burning gas, but will propagate an explosion originating in other media. Dusts giving pressures falling

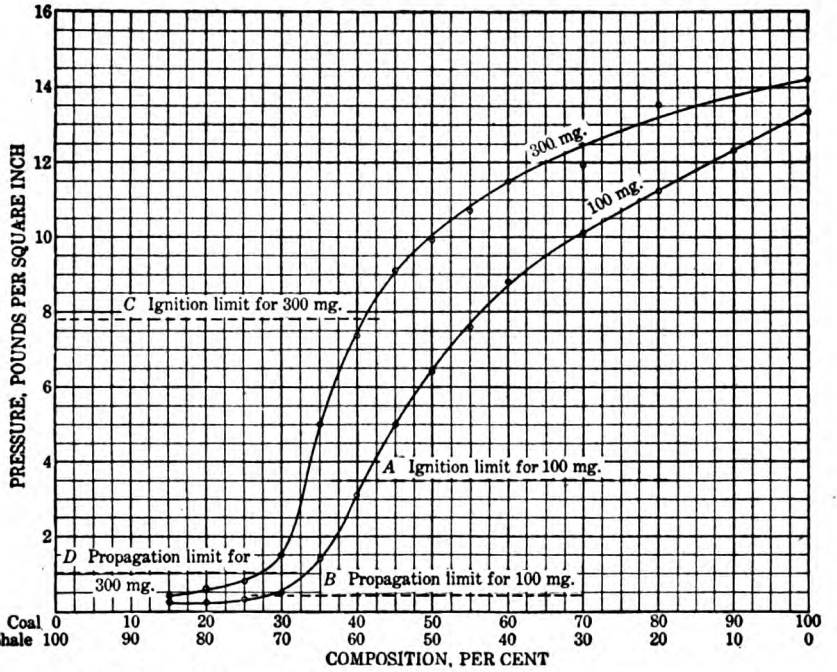


FIGURE 3.—Relation between inflammability and composition of mixtures of experimental mine coal dust and shale dust.

below the line *B* will not be ignited by a flame, electric arc, or burning gas, and will not propagate an explosion already set up in other media.

If the pressure developed by 100 mg. of dust is less than one pound, the test is repeated with 300 mg. The reason for this is evident from Figure 3. With 300 mg. of dust greater pressures are obtained and it is easier to distinguish between dusts that are capable of propagating an explosion and those that are not. It has been found best to use 300 mg. of dust for determining propagation limits and 100 mg. for determining ignition limits.

As all samples used in establishing the curves from which the interpretation of results is made were prepared from 200-mesh

Generated on 2024-09-28 16:20 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

material, interpretation of results is based only on samples that pass a 200-mesh screen. A sample of dust from coal from the experimental mine ground to 200 mesh and termed "Pittsburgh standard dust" is used as a standard. A large sample is prepared and kept in a tightly sealed glass jar. Samples stored in this way for more than a year show no change in inflammability.

Experience with the apparatus in its present form has shown that the variations obtained from day to day in the pressure developed by the standard dust cover a range of 0.6 pound, that is, 13 to 13.6 pounds, inclusive. The great majority of the values fall within the limits of 13.1 and 13.4 pounds.

Better agreement between individual observations with a given sample of highly inflammable dust, such as Pittsburgh standard dust, is obtained by taking smaller quantities of dust. The quantities used, 100 and 300 mg., were adopted because they give greater sensitiveness and accuracy with less inflammable dusts.

INFLAMMABILITY OF MIXTURES OF COAL DUST AND SHALE DUST.

In view of the importance of rock dust in preventing or limiting dust explosions a knowledge of the inflammability of mixtures of coal dust and of rock dust is of value. In particular it is desirable to have a reliable laboratory method for determining the percentages of rock dust that must be added to various coal dusts to render the mixtures incapable of propagating and giving rise to explosions, that is, a method for determining the limits of ignition and propagation for such dusts.

The five coals whose limits of ignition and propagation have been determined at the experimental mine were used for this study. The proximate analyses of these coals are given in the following table:

Proximate analyses of coals used.

Mine.	Nearest town.	State.	Bed.	Moisture.	Volatile matter.	Fixed carbon.	Ash.
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Experimental..	Bruceton.....	Pa.....	Pittsburgh.....	2.13	32.75	59.19	5.93
Lucerne.....	Homer City...	...do.....	Upper Freeport...	1.00	29.65	59.48	9.87
Layland.....	Layland.....	W. Va...	Fire Creek.....	.57	20.03	72.84	6.56
Eccles No. 3....	Eccles.....	...do.....	Beckley.....	.83	18.15	71.12	9.90
Maryland.....	St. Michaels...	Pa.....	Lower Kittanning.	.49	16.01	75.80	7.70

The shale dust used in preparing the coal-shale mixtures contains 99 per cent of incombustible matter. The remaining 1 per cent consists principally of carbon, with a small amount of organic hydrogen. Both coal and shale were ground to 200 mesh and mixed in the proper proportions in the laboratory.

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

The combustible gas used was the natural gas supplied to the city of Pittsburgh; it had the following composition:[a]

Analysis of natural gas used.

	Per cent.
Methane	84.7
Ethane	9.4
Propane	3.0
Butane (chiefly)	1.3
Nitrogen	1.6

The results of experiments with the coal from the experimental mine, represented graphically in figure 3, have been discussed in the preceding pages. The results for the other coals are represented in figures 4, 5, 6, and 7.

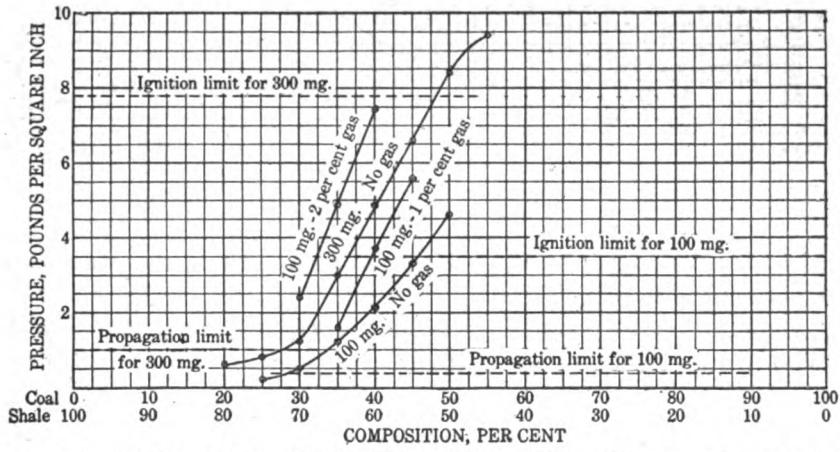

PRESSURE, POUNDS PER SQUARE INCH
10
8
6
4
2
Ignition limit for 300 mg.
Ignition limit for 100 mg.
Propagation limit for 300 mg.
Propagation limit for 100 mg.
100 mg.-2 per cent gas
300 mg. No gas
100 mg.-1 per cent gas
100 mg. No gas
Coal 0 10 20 30 40 50 60 70 80 90 100
Shale 100 90 80 70 60 50 40 30 20 10 0
COMPOSITION, PER CENT

FIGURE 4.—Relation between inflammability and composition of Lucerne mine coal-dust and shale-dust mixtures.

In these figures the curves marked "100 mg. no gas" and "300 mg. no gas" give the pressures developed in air by 100 mg. and by 300 mg. of various mixtures of the particular dust with shale dust. The curve marked "100 mg. 1 per cent gas" gives the pressure developed in an atmosphere containing 1 per cent natural gas, by 100 mg. of various shale-dust mixtures, and the curve marked "100 mg. 2 per cent gas" gives the pressures developed in the presence of 2 per cent of natural gas.

The four horizontal lines in each figure are drawn at the same distances above the x axis as the lines in figure 3, and their significance is the same. The line marked "ignition limit for 100 mg.," for example, represents the pressure developed by 100 mg. of the ignition-limit mixture of the experimental mine dust. If it be assumed that the limit mixture for any other coal develops the same pressure as the

[a] Burrell, G. A., and Seibert, F. M., Analyses of natural gas and illuminating gas by fractional distillation at low temperatures: Tech. Paper 104, Bureau of Mines, 1915, 41 pp.

Generated on 2024-09-28 16:12 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

limit mixture of experimental mine dust, then the intersection of this line with the curve marked "100 mg. no gas" gives the composition of the ignition-limit mixture of the dust in question, and its intersection with the curve marked "100 mg. 1 per cent gas" gives the com-

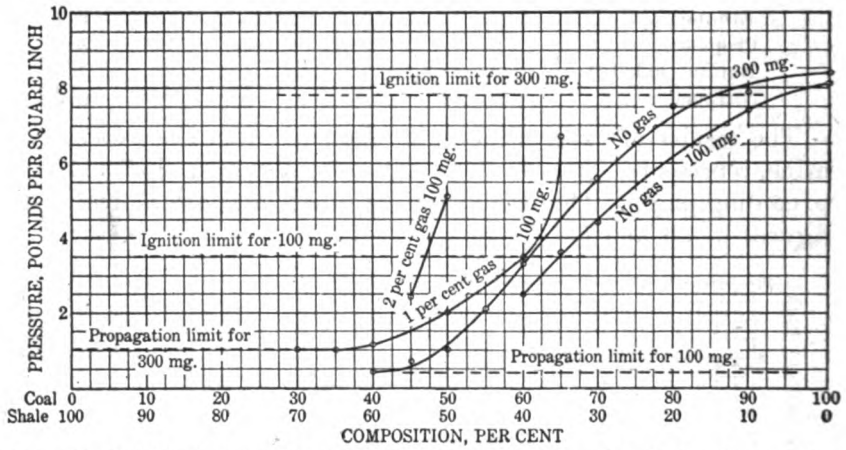

PRESSURE, POUNDS PER SQUARE INCH
Ignition limit for 300 mg.
Ignition limit for 100 mg.
Propagation limit for 300 mg.
Propagation limit for 100 mg.
300 mg.
No gas
100 mg.
2 per cent gas
1 per cent gas
Coal 0 10 20 30 40 50 60 70 80 90 100
Shale 100 90 80 70 60 50 40 30 20 10 0
COMPOSITION, PER CENT

FIGURE 5.—Relation between inflammability and composition of Layland mine coal-dust and shale-dust mixtures.

position of the ignition-limit mixture of the dust in the presence of 1 per cent natural gas.

In figure 4, for example, the line representing the pressure developed by 100 mg. of the ignition-limit mixture of Pittsburgh coal

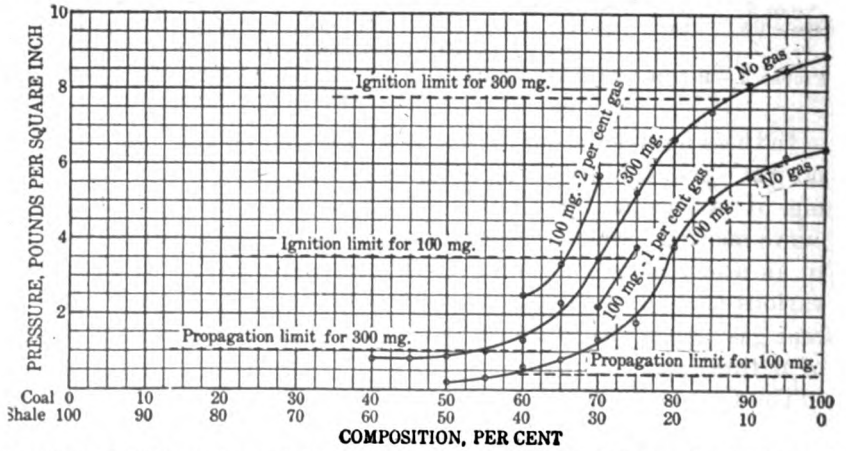

PRESSURE, POUNDS PER SQUARE INCH
Ignition limit for 300 mg.
Ignition limit for 100 mg.
Propagation limit for 300 mg.
Propagation limit for 100 mg.
No gas
2 per cent gas
300 mg.
1 per cent gas
100 mg.
Coal 0 10 20 30 40 50 60 70 80 90 100
Shale 100 90 80 70 60 50 40 30 20 10 0
COMPOSITION, PER CENT

FIGURE 6.—Relation between inflammability and composition of Eccles No. 3 mine coal-dust and shale-dust mixtures.

and shale intersects the curves for 100 mg. of dust at points corresponding to 54, 61, and 68 per cent shale, the percentages of shale in the ignition-limit mixtures of the Lucerne mine coal with, respectively, 0, 1, and 2 per cent natural gas present in the atmosphere. Similarly, the propagation limit in an atmosphere containing no

Generated on 2024-09-28 16:22 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

combustible gas is found to be the mixture containing 72 per cent shale. With the Lucerne mine coal tests with 100 mg. of dust (fig. 4) yield the same values for the propagation and ignition limits as tests with 300 mg. With the Eccles mine coal (fig. 6) and Maryland mine coal (fig. 7) a satisfactory agreement is found between limits determined with 100 mg. and 300 mg., respectively. As already stated, however, the limit of propagation can be determined more reliably with 300 mg. of dust and the limit of ignition with 100 mg.

The following table gives the values of the ignition limit and the propagation limit as determined in the laboratory and in the experimental mine, and the inflammability of the coal dust used in preparing the coal-shale mixtures. These limits, as determined at the

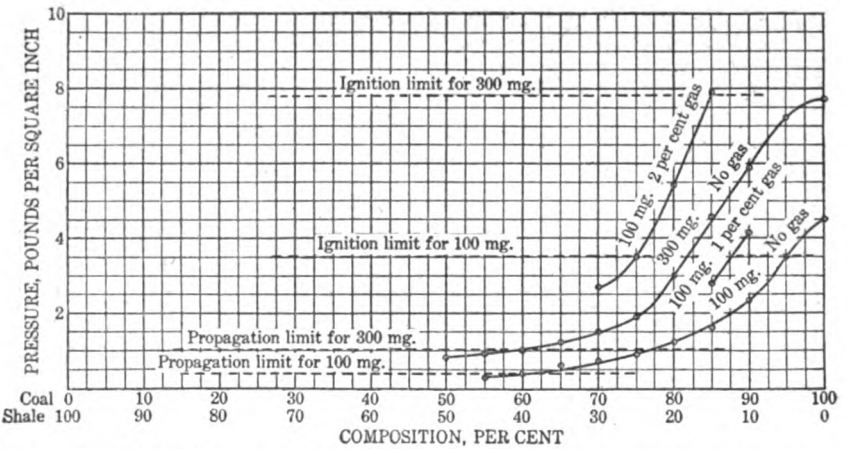

PRESSURE, POUNDS PER SQUARE INCH
10
8
6
4
2
Ignition limit for 300 mg.
Ignition limit for 100 mg.
Propagation limit for 300 mg.
Propagation limit for 100 mg.
100 mg. 2 per cent gas
No gas
300 mg. 1 per cent gas
100 mg. 1 per cent gas
No gas
100 mg.
Coal 0 10 20 30 40 50 60 70 80 90 100
Shale 100 90 80 70 60 50 40 30 20 10 0
COMPOSITION, PER CENT

FIGURE 7.—Relation between inflammability and composition of Maryland mine coal-dust and shale-dust mixtures.

experimental mine, are taken from the tentative curves obtained by plotting the results of the tests, ignition or nonignition, propagation or nonpropagation with reference to the percentage of incombustible matter and the ratio of volatile combustible to total combustible in the dust.

Propagation and ignition limits of coals used.

Mine.	Percentage of shale in limit mixtures.								Inflammability of pure coal, pounds per square inch.
	Propagation.		Ignition.		Ignition with 1 per cent gas.		Ignition with 2 per cent gas.		
	Laboratory.	Mine.	Laboratory.	Mine.	Laboratory.	Mine.	Laboratory.	Mine.	
Experimental	.....	73	.....	59	.....	65	.....	72	13.3
Lucerne	72	64	54	55	61	62	68	69	11.8
Layland	50	53	35	42	40	52	53	62	8.1
Eccles No. 3	44	48	21	35	26	47	35	58	6.4
Maryland	40	43	5	28	12	40	25	50	2.7

Generated on 2024-09-28 16:12 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

It will be seen that the values for propagation limits determined in the laboratory agree satisfactorily with those of the large-scale experiments at the mine. In fact, with one exception the differences are within the limit of accuracy with which the limits can be established in the experimental mine.

The laboratory values for limits of ignition do not agree so well with those found at the mine, the former leading to lower percentages of shale in the limit mixtures. The lower the inflammability of the coal the greater is the difference between the ignition limits determined in the laboratory and in the mine.

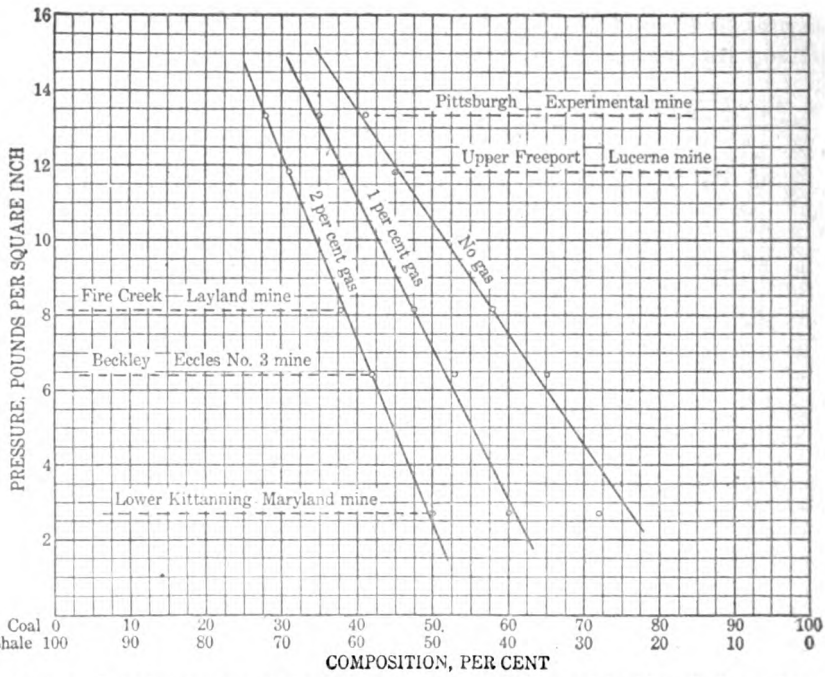


FIGURE 8.—Relation between inflammability and composition of ignition limit mixtures.

A definite relation is found to exist between the inflammability of coal dust as indicated by the pressure in the laboratory apparatus and the limits of ignition and propagation found in the mine. The relation is shown graphically in figures 8 and 9, in which the composition of the limit mixture is plotted as abscissas and the pressure developed in the laboratory apparatus as ordinates.

Of the three curves shown in figure 8 the one on the right represents the relation between the pressures developed in the laboratory apparatus and the percentage of coal that must be contained in the coal-shale dust mixture in order that the dust when suspended in normal air may be ignited by the flame of a blown-out shot. The other two curves represent the same relation in atmospheres contain-

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

ing 1 per cent and 2 per cent natural gas. With one exception the points fall on straight lines. It follows from this that within the range of inflammability of the dusts given the pressure developed in the laboratory apparatus is directly proportional to the percentage of shale that must be exceeded in the mixture to prevent its ignition by the flame of a blown-out shot.

In figure 9 the abscissas represent the composition of the limit mixtures for propagation of an explosion in normal air. The progagation limits in atmospheres containing combustible gas have not been determined.

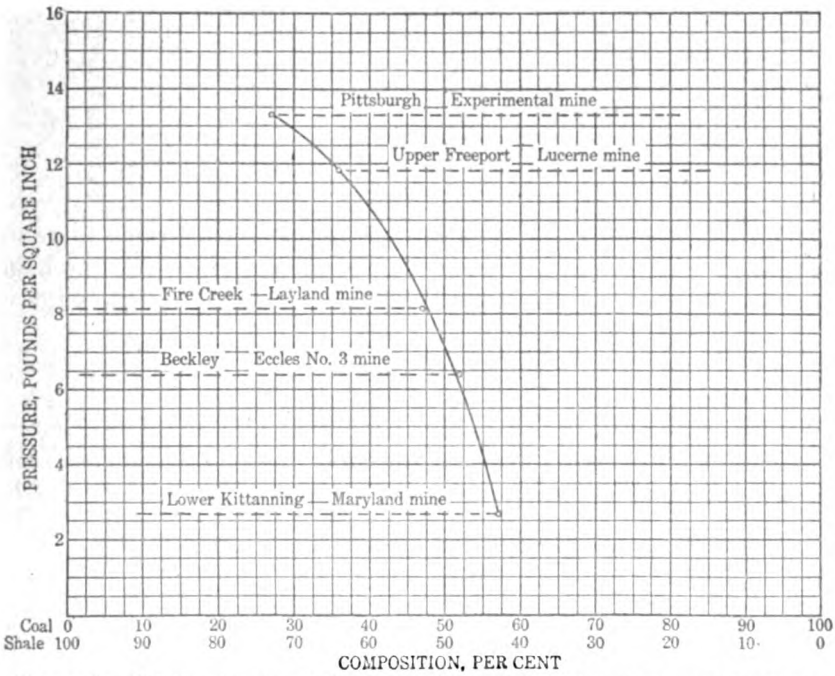


FIGURE 9.—Relation between inflammability and composition of propagation limit mixtures.

As regards the shape of the curves below the lowest points plotted, although ignition and propagation limits have not been determined for coals less inflammable than the Lower Kittanning coal from the Maryland mine, it seems likely that if continued downward the curves would bend rather sharply to the right.

INFLAMMABILITY OF DUST IN AIR CONTAINING SMALL AMOUNTS OF NATURAL GAS.

The modification of the method whereby the inflammability of dusts in an atmosphere containing a definite percentage of combustible gas can be determined, and the results of experiments on the

Generated on 2024-09-28 16:16 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

effect of 1 per cent and 2 per cent of such gas on the ignition limits of Upper Freeport and New River coal dust have been described. Although these experiments were made with 100 mg. portions of 200-mesh dust, the experiments that follow were made with 300 mg. of dust and the samples, except one series with Lykens Valley, Pa., anthracite and one with anthracite from the Bankhead mine, British Columbia, were ground at the experimental mine. The dust contains a considerable amount of coarse dust, as will be seen from the following table:

Sizing tests of coal ground for tests at experimental mine.

Through—	On—	Per cent.
20 mesh	40 mesh	3.05
40 mesh	60 mesh	2.84
60 mesh	80 mesh	1.47
80 mesh	100 mesh	.95
100 mesh	200 mesh	16.75
200 mesh		74.94

On this account the results are not strictly comparable to results obtained with samples ground in the laboratory to 200 mesh and can not be used for the determination of ignition and propagation limits.

In all cases the "combustible gas" is the natural gas used in Pittsburgh.

Figure 10 shows the results of experiments on two samples of Lykens Valley anthracite—one ground at the experimental mine and one ground in the laboratory to 200 mesh.

Proximate analysis of typical Lykens Valley anthracite.

Constituent.	Per cent.
Moisture	1.18
Volatile matter	10.87
Fixed carbon	73.46
Ash	14.49

The curve for the 200-mesh dust rises slowly as the percentage of gas in the atmosphere of the explosion globe increases to the point corresponding to 1.5 per cent of gas, and then bends sharply upward. The pressure developed when no combustible gas is present indicates that in normal air the dust will propagate an explosion, but will not be ignited by the flame of a blown-out shot. In the presence of 2 per cent of gas the dust is very liable to be ignited by such a flame. With 3 per cent of gas present the pressure developed is slightly greater than that developed by the Pittsburgh standard dust in a nongaseous atmosphere.

Generated on 2024-09-28 16:18 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

The effect of dust particles larger than 200-mesh in the dust tested is strikingly shown by the curve for the dust ground at the experi-

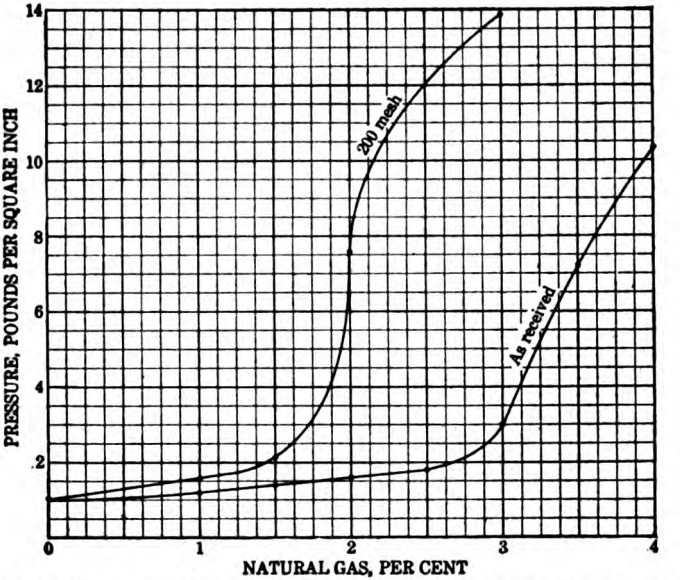


FIGURE 10.—Effect of presence of combustible gas on inflammability of Lykens Valley, Pa., anthracite dust.

mental mine, this curve lying below that for the 200-mesh dust. The presence of 3 per cent of gas is required to produce a marked upward bend in the curve.

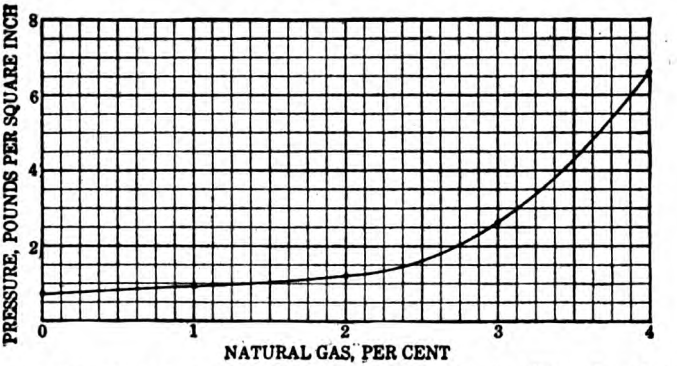


FIGURE 11.—Effect of presence of combustible gas on inflammability of anthracite dust from Bankhead mine, British Columbia.

The effect of combustible gas on the inflammability of anthracite dust from the Bankhead mine, British Columbia, is shown in figure 11. The proximate analysis of the Bankhead anthracite is given in the following table:

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

Proximate analysis of dust from the Bankhead mine.

Constituent.	Per cent.
Moisture	0.33
Volatile matter	10.75
Fixed carbon	80.34
Ash	8.58

Figures 12 and 14 show the effect of the presence of natural gas on the inflammability of mixtures of Pittsburgh coal and of New River, W. Va., coal with shale dust. In both cases the effect of the gas increases as the percentage of coal in the dust mixture is raised.

Figures 13 and 15 show the effect of the presence of natural gas on the inflammability of a mixture consisting of 25 per cent Pitts-

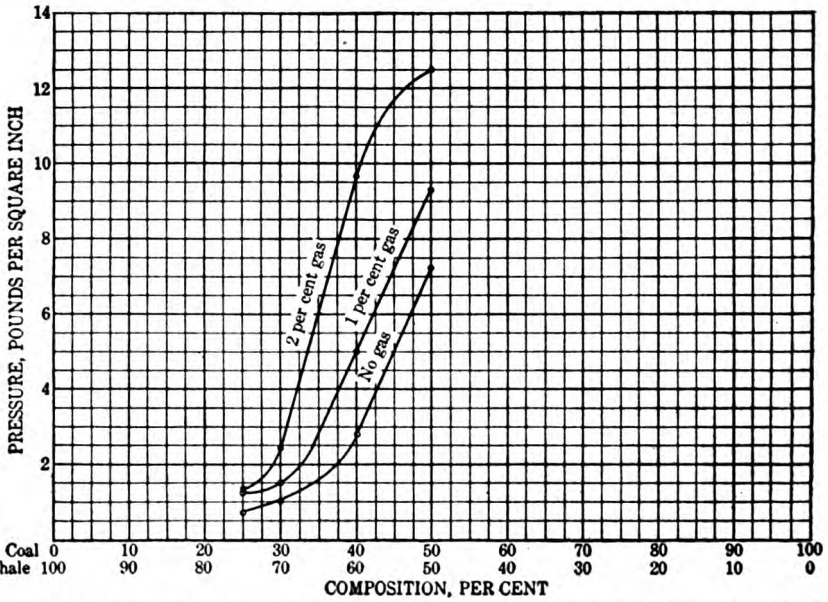


FIGURE 12.—Effect of presence of natural gas on the inflammability of mixtures of experimental mine coal dust and shale dust.

burgh coal dust and 75 per cent shale dust, and of a mixture containing 40 per cent New River, W. Va., coal dust and 60 per cent shale dust, respectively.

The results of these experiments indicate that dusts too low in inflammability to propagate an explosion in normal air may readily do so in the presence of 2 to 3 per cent of natural gas, and the percentage of rock dust that must be added to coal dust to prevent its giving rise to or propagating an explosion is considerably greater in mines where gas is likely to be present than in nongaseous mines. These conclusions are in complete agreement with results of tests at the experimental mine.

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

RESULTS OF INFLAMMABILITY TESTS OF VARIOUS COAL DUSTS.

It can readily be appreciated that the determination of the inflammability of coal dusts at the experimental mine or by other large-scale tests is expensive and slow, so that comparatively few types of coal can be studied, and data on a given coal can not be quickly obtained. The use of the laboratory method described provides a means of obtaining reliable information concerning the relative inflammability of coals in a very short time and at small expense.

About 600 coals taken from mines in 21 different States and two Provinces of Canada have been tested according to this method. In accordance with the scheme outlined in the introduction to this paper, these coals have been classified according to the pressures de-

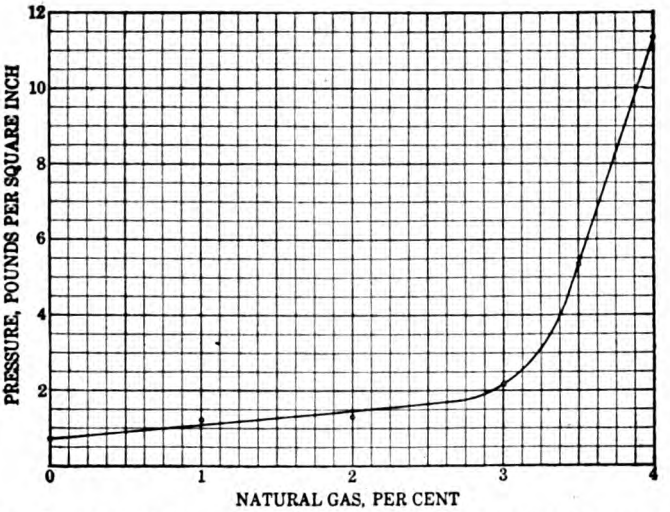


FIGURE 13.—Effect of presence of natural gas on inflammability of a mixture consisting of Pittsburgh coal dust, 25 per cent, and shale dust, 75 per cent.

veloped. The data presented were collected during one year. Such an amount of information could have been obtained by large-scale testing only by expending a large amount of money and by taking a correspondingly long period of time.

The types of material tested by this method comprise standard face samples of coal, road and rib dusts, and mechanical mixtures of coal and shale dusts.

The results of inflammability tests and the proximate analyses of a number of samples of dust of face samples of coal are given in Table 1 and corresponding data for road and rib dusts in Table 2. All inflammability tests were made on samples ground to 200-mesh and with a few exceptions noted in the second column of each table

Generated on 2024-09-28 16:13 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

on 100 mg. portions. In both tables the samples are arranged in the order of their inflammability.

No definite relation is to be found between inflammability and chemical composition. Usually the higher the content of volatile matter the greater is the inflammability.

It is worthy of note that, except the anthracite dusts, only six dusts out of more than 600 tested were found to be in that class of dusts which can not be ignited by a blown-out shot and will not propagate an explosion set up in other media. Many anthracite dusts, however,

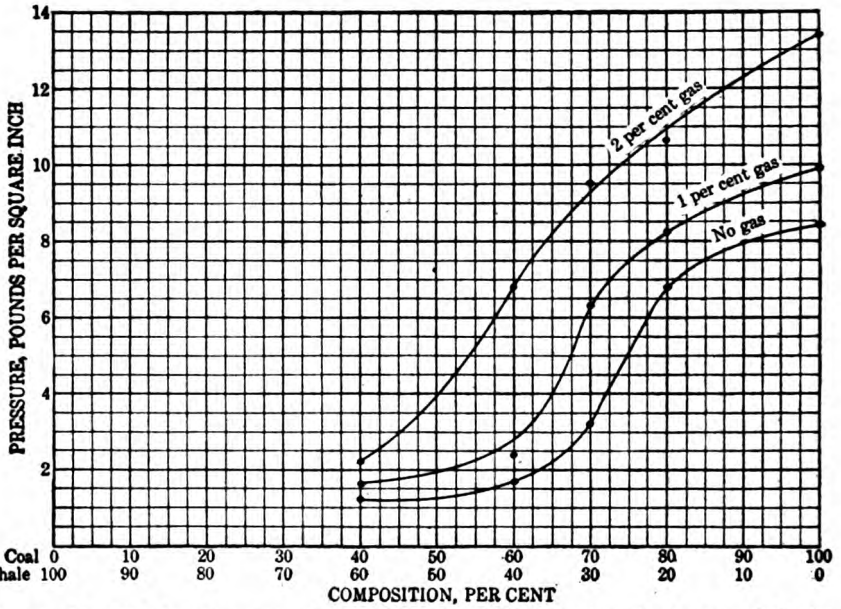


FIGURE 14.—Effect of presence of natural gas on inflammability of mixtures of Eccles No. 3 mine coal dust and shale dust.

fall in this class, though some of them were found to be capable of propagating an explosion.

The necessity for the verification of the results of laboratory tests by means of large-scale tests has been emphasized in Bureau of Mines Bulletins 50[a] and 102.[b] The value of the tests just mentioned is greatly enhanced by the relation established between results obtained in the laboratory and those obtained in the experimental mine.

It has been previously stated that in all the coals tested the order of inflammability as measured by limits of ignition and propagation in the laboratory test agrees with the determinations at the mine.

[a] Frazer, J. C. W., Hoffman, E. J., and Scholl, L. A., jr., A laboratory study of the inflammability of coal dust, 1913, 60 pp.

[b] Clement, J. K., and Scholl, L. A., jr., The inflammability of Illinois coal dusts, 1915, 74 pp.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

Since the preparation of this report large-scale tests made at the experimental mine have shown how greatly the size of the dust particles affects the relative inflammability of the dust. Dust from the Pittsburgh coal, when so fine that 85 to 90 per cent passes through a 200-mesh sieve, requires an amount of shale dust equal to four times

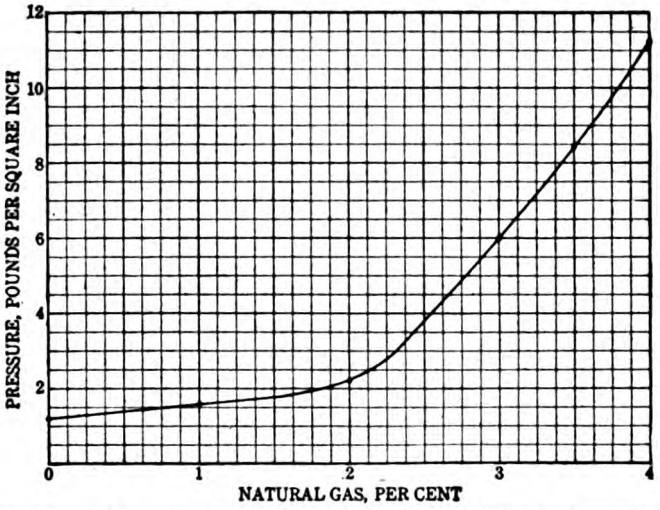


FIGURE 15.—Effect of presence of natural gas on inflammability of a mixture consisting of Eccles No. 3 mine coal dust, 40 per cent, and shale dust, 60 per cent.

its weight to prevent propagation of flame; when only 40 per cent of the coal dust is as fine as 200 mesh three times as much shale dust is needed, and when the percentage of 200-mesh coal dust is reduced to 20 the quantity of shale dust need be only twice that of the coal dust.

Generated on 2024-09-28 16:19 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:17 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 1.—*Inflammability of dust prepared from face samples.*

[Samples air dried.]

Mine No.	Test No.	State.	County	Coal bed.	Kind of coal.	Proximate analysis.				Oxygen.	Calorific value of coal.	Inflammability.
						Moisture.	Volatile matter.	Fixed carbon.	Ash.			
						Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*B. t. u.*	*Lbs. per sq. in.*
1	612	Utah	Carbon	Castlegate	Bituminous	2.13	44.10	47.52	6.25	12.38	13,223	19.9
2	504	do	do	do	do	2.33	46.20	46.02	5.45	11.24	13,513	19.5
3	611	do	do	"No. 2"	do	2.15	43.85	47.37	6.63	11.93	13,244	19.0
4	834	Kentucky	Laurel	"No. 1"	do	1.96	40.59	50.17	7.28	7.27	13,525	18.2
5	887	Wyoming	Fremont	"Mesa Verde"	Subbituminous	7.69	39.46	44.02	8.83	20.27	10,969	18.1
6	618	do	Monarch	Monarch	do	9.68	39.97	44.72	5.63	23.30	11,036	18.0
7	888	Tennessee	Anderson	Coal Creek	Bituminous	1.35	40.78	53.82	4.05	.....	14,330	17.8
8	953	Indiana	Vermilion	No. 5	do	5.09	42.14	42.78	9.99	12.03	12,334	17.7
9	336	New Mexico	McKinley	"Aztec"	Subbituminous	6.49	40.86	43.55	9.10	16.98	11,741	17.5
10	978	Utah	Carbon	"Hiawatha"	Bituminous	3.77	43.71	46.46	6.06	13.83	12,998	17.3
11	936	Washington	Kittitas		do	3.73	39.52	47.45	9.30	.....	12,730	17.3
12	515	North Dakota	Williams	"Middle"	Lignite	12.48	38.32	41.85	7.35	28.31	9,666	17.2
13	665	do	Morton		do	8.60	41.03	39.54	10.83	22.98	9,965	17.0
14	884	Kentucky	Letcher	Elkhorn	Bituminous	1.45	36.88	58.39	3.28	7.92	14,382	16.9
15	952	Tennessee	Campbell	Blue Gem	do	2.52	39.76	55.63	2.09	10.41	14,090	16.8
16	835	Kentucky	Perry	"Hazard No. 7"	do	2.10	36.28	54.24	7.38	9.25	13,516	16.7
17	973	New Mexico	San Juan	Carbonero	Subbituminous	5.73	41.15	42.57	10.55	.....	11,718	16.7
18	818	Tennessee	Scott	No. 4	Bituminous	1.97	39.21	52.18	6.64	8.33	13,651	16.7
19	471	Oklahoma	Latimer	Lower Hartshorne	do	2.02	37.08	57.75	3.15	7.63	14,389	16.6
20	833	Kentucky	Perry	Haddix or No. 6	do	2.30	36.00	53.36	8.34	9.33	13,216	16.3
21	741	Indiana	Vanderburgh	No. 5	do	2.15	38.60	48.20	11.05	10.48	12,395	15.9
22	696	Ohio	Belmont	No. 8 or Pittsburgh	do	1.93	43.97	44.85	9.25	8.26	13,099	15.8
23	987	West Virginia	Harrison	Redstone	do	1.50	38.90	51.50	8.10	7.99	13,613	15.7
24	894	Kentucky	Knox	Pean	do	1.95	36.30	54.56	6.19	9.23	13,723	15.5
25	889	Tennessee	Morgan	Walden Ridge	do	.73	32.92	58.92	7.43	.....	14,213	15.4
26	502	Utah	do	Unnamed	do	10.30	29.98	38.67	21.05	20.76	8,950	15.4
27	782	Montana	Fallon	"Kerr"	Subbituminous	10.63	37.52	40.90	10.95	.....	9,430	15.4
28	997	Colorado	Routt	"Harris"	do	7.89	38.96	46.76	6.39	19.17	11,790	15.3
29	752	Indiana	Gibson	No. 5	Bituminous	2.15	40.70	47.70	9.45	9.44	12,805	15.3
30	398	Oklahoma	Pittsburg	Lower Hartshorne	do	1.57	39.01	53.12	6.30	.....	13,822	15.3
31	885	Kentucky	Perry	"Hazard No. 4"	do	1.84	37.49	55.30	5.37	8.50	13,878	15.1
32	335	New Mexico	McKinley	"Myers"	Subbituminous	5.55	39.45	46.92	8.08	15.16	12,152	15.1
33	591	Montana	Musselshell	Unnamed	do	6.18	32.57	45.50	15.75	15.84	10,699	15.1
34	897	Kentucky	Bell	Hickory	Bituminous	2.04	37.51	55.17	5.28	8.47	13,988	15.0
35	352	North Dakota	Williams	"Upper"	Lignite	16.10	36.00	39.84	8.06	29.30	9,245	14.8

Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:17 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

36	948	Tennessee	Campbell	Red Ash	Bituminous	2.27	39.08	52.55	6.10	8.67	13,574	14.8
37	401	Oklahoma	Pittsburg	Lower Hartshorne	do	1.66	38.94	52.74	6.66	7.54	13,822	14.5
38	829	Tennessee	Morgan	Jellico	do	1.25	37.90	55.67	5.18	6.14	14,281	14.5
39	689	Ohio	Belmont	Waynesburg	do	2.20	36.10	45.12	16.58	8.22	11,860	14.4
40	986	Virginia	Wise	Pardee	do	1.58	36.60	56.14	5.68	6.96	14,139	14.4
41	995	Colorado	Routt		Subbituminous	7.44	38.66	48.68	5.22		12,121	14.3
42	464	Montana	Chouteau		do	11.83	31.52	44.45	12.20	23.14	9,819	14.0
43	956	Alabama	Jefferson	Black Creek	Bituminous	1.07	32.33	63.84	2.76	5.38	14,859	13.9
44	767	Illinois	Franklin	No. 6	do	4.25	34.38	51.54	9.83	12.65	12,382	13.9
45	984	do	Montgomery	No. 6	do	5.05	38.23	44.04	12.68	12.57	11,576	13.9
46	503	Virginia	Buchanan	Mohawk	do	.90	32.75	63.27	3.08	5.50	14,942	13.9
47	1002	West Virginia	Clay	No. 5, block	do	1.43	35.92	55.00	7.65	7.77	13,727	13.8
48	584	Alabama	Shelby	Helena	do	1.42	36.73	54.24	7.61	7.66	13,793	13.7
49	925	Tennessee	Campbell	"Monarch"	do	2.08	37.80	49.06	11.06	7.92	12,892	13.7
50	776	Illinois	Perry	No. 6	do	3.18	35.26	52.93	8.63	12.77	12,598	13.6
51	766	Pennsylvania	Allegheny	Pittsburgh	do	1.10	35.93	57.47	5.50		14,117	13.6
52	976	West Virginia	Nicholas		do	1.34	34.79	58.59	5.28	7.67	14,278	13.6
53	615	Montana	Fergus	Unnamed	Subbituminous	9.83	32.32	44.10	13.75	21.30	9,904	13.5
54	594	Alabama	Jefferson	Pratt	Bituminous	.58	28.92	64.87	5.63	3.89	14,666	13.4
55	808	do	do	Mary Lee	do	.83	30.20	58.87	10.10	4.63	13,700	13.3
56	653	Oklahoma	Pittsburg	Lower Hartshorne	do	1.48	36.57	55.65	6.30	7.56	13,977	13.3
57	403	Virginia	Buchanan		do	1.43	28.75	62.70	7.12	5.77	14,090	13.3
58	999	Illinois	Peoria	No. 5	do	2.33	40.10	45.99	11.58	10.32	12,409	13.2
59	751	Alabama	Bibb	Thompson	do	1.30	36.83	53.79	8.08	8.70	13,435	13.1
60	505	Pennsylvania	Allegheny	Pittsburgh	do	1.37	35.50	55.14	7.63		13,800	13.1
61	740	Ohio	Guernsey	Upper Freeport	do	2.70	36.85	54.70	5.75	10.24	13,466	12.9
62	806	Tennessee	Overton	"Bon Air No. 2"	do	1.28	36.37	51.77	10.58	5.75	13,282	12.9
63	816	do	Roane	Sewanee	do	.95	28.45	58.55	12.05	5.63	13,322	12.8
64	616	New Mexico	Socorro		do	9.08	37.17	42.62	11.13	25.87	9,117	12.6
65	1004	Pennsylvania	Indiana	B or Miller	Semibituminous	.60	21.58	69.66	8.16	2.19	14,366	12.5
66	739	Colorado	Las Animas	"Cokedale"	Bituminous	.68	26.42	54.95	17.95	5.77	12,407	12.3
67	454	New Mexico	Colfax	"Raton"	do	1.25	37.10	47.17	14.48	8.60	12,605	12.3
68	772	Alabama	Tuscaloosa	Jagger	do	.57	26.33	64.25	8.85	3.80	14,146	12.0
69	779	Ohio	Belmont	Uniontown	do	2.15	35.13	46.97	15.75	9.74	11,975	11.8
67	462	New Mexico	Colfax	"Raton"	do	1.58	36.72	47.72	13.98	8.39	12,830	11.3
70	974	Pennsylvania	Clearfield	D or Moshanon	do	.78	25.19	64.78	9.25		14,083	11.3
71	985	Tennessee	Marion	"Kelley"	do	1.11	28.32	63.21	7.36	4.61	14,146	11.2
72	431	Alberta, Canada			do	1.03	30.00	58.12	10.85			10.6
73	762	Maryland	Allegany	Tyson or Upper Sewickley	Semibituminous	.65	21.00	70.15	8.20	2.86	14,242	10.5
74	831	Missouri	Bates	Lower Rich Hill	Bituminous	3.78	29.70	33.27	33.25		8,075	10.5
75	470	Pennsylvania	Somerset	"A"	Semibituminous	.93	21.35	67.22	10.50	4.28	13,604	10.1
76	529	Arkansas	Logan	Paris	do	.60	17.55	71.65	10.20	1.52	13,774	9.6
72	377	Alberta, Canada			Bituminous	.93	27.42	55.70	15.95	7.09	12,386	9.2
77	961	West Virginia	Fayette	Fire Creek	Semibituminous	.49	21.06	71.45	7.00	2.55	14,501	9.1
78	764	Pennsylvania	Somerset	Miller or B	do	.55	18.60	73.85	7.00	2.44	14,528	8.8
79	425	West Virginia	Raleigh	Beckley	do	.98	18.55	73.94	6.53	3.45	14,490	8.7
72	376	Alberta, Canada			Bituminous	.92	26.08	53.20	19.80	6.97	11,824	8.6
80	958	West Virginia	McDowell	Sewell	do	.61	20.52	74.40	4.47	3.59	14,926	8.5
81	947	Pennsylvania	Cambria	Lower Freeport or D	Semibituminous	.54	18.74	72.04	8.68	2.19	14,130	7.9
82	774	do	do	Upper Freeport or E	do	.55	18.20	72.75	8.50	2.47	14,245	7.8

Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 1.—*Inflammability of dust prepared from face samples*—Continued.

Mine No.	Test No.	State.	County.	Coal bed.	Kind of coal.	Proximate analysis.				Oxygen.	Calorific value of coal.	Inflammability.
						Moisture.	Volatile matter.	Fixed carbon.	Ash.			
						Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*B. t. u.*	*Lbs. per sq. in.*
83	528	Arkansas	Franklin	Denning	Semibituminous	0.65	15.80	76.17	7.38	2.05	14,170	7.6
84	469	Pennsylvania	Somerset	Miller or B	do	.73	17.62	75.02	16.63	2.70	14,492	7.3
85	721	West Virginia	McDowell	Pocahontas No. 3	do	.48	16.75	78.04	4.73	2.74	14,899	7.1
86	941	Pennsylvania	Cambria	Upper Kittanning or C'	do	.63	16.47	73.25	9.65	2.12	13,918	6.0
87	390	Oklahoma	Le Flore		do	.61	16.82	73.72	8.85	2.55	14,085	5.6
88	a 706	Pennsylvania	Dauphin	Lykens	Anthracite	.43	9.39	81.49	8.69		13,999	1.0
89	a 426	Washington	Whatcom		do	1.85	7.65	77.95	12.55	2.90	12,924	0.9
90	a 354	Virginia	Pulaski	"Upper Large"	Semibituminous	.95	11.78	64.21	23.06	4.00	11,473	0.7

a 300 mg. used for test.

Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:16 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 2.—*Inflammability of road and rib dusts.*

Mine No.[a]	Test No.	State.	County.	Coal bed.	Kind of coal.	Character of dust.	Proximate analysis.				B. t. u.	Inflammability.
							Moisture.	Volatile matter.	Fixed carbon.	Ash.		
							Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		*Lbs. per sq. inch.*
6	329	Wyoming	Sheridan	Monarch	Subbituminous	Rib	9.18	37.17	46.57	7.08	10,746	16.7
91	980	Indiana	Vermilion	No. 3	Bituminous	Road	1.70	37.75	44.45	16.10	11,869	16.0
92	964	do	Vigo	No. 5	do	do	1.78	36.65	42.55	19.02	11,335	15.9
92	979	do	do	do	do	do	1.75	35.45	41.30	21.50	10,984	15.4
93	805	do	do	do	do	do	1.92	35.58	38.60	23.90	10,553	14.5
6	330	Wyoming	Sheridan	Monarch	Subbituminous	Rib	6.08	32.22	39.42	22.28	9,032	13.8
48	576	Alabama	Shelby	Helena	Bituminous	Road	1.28	32.47	51.95	14.30	12,551	13.6
94	341	Iowa	Monroe	No. 2 or Buxton	do	From timbers	4.83	35.82	39.72	19.63	10,534	13.5
95	537	Montana	Carbon	"No. 3"	Subbituminous	Road	5.81	31.04	31.01	32.14	7,961	13.3
10	971	Utah	Emery	"Hiawatha"	Bituminous	do	3.53	42.37	45.27	8.83	12,706	13.2
67	442	New Mexico	Colfax	"Blossburg"	do	Float	1.50	31.38	37.87	29.25	10,298	13.2
96	549	Kentucky	Henderson	No. 9	do	Road	5.18	33.87	39.35	21.50	9,927	13.0
97	975	Indiana	Sullivan	"No. 5"	do	do	5.95	34.30	42.64	17.11	10,391	12.8
98	940	do	do	do	do	do	2.25	36.35	41.94	19.46	11,185	12.7
99	391	Pennsylvania	Allegheny	Upper Freeport	do	do	1.45	28.15	43.22	27.18	10,604	12.3
48	581	Alabama	Shelby	Helena	do	Rib	1.48	29.87	53.25	15.40	.....	12.2
100	920	Illinois	Sangamon	No. 5	do	Road	3.78	34.67	35.52	26.03	9,724	12.0
101	966	Indiana	Vermilion	do	do	do	3.01	31.57	36.67	28.75	8,953	12.0
102	789	Oklahoma	Pittsburg	Lower Hartshorne	do	do	1.70	29.03	40.42	28.85	9,979	11.9
103	824	West Virginia	Fayette	Sewell	do	do	.78	22.02	66.60	10.60	13,709	11.9
100	922	Illinois	Sangamon	No. 5	do	do	3.08	32.87	34.43	29.62	9,099	11.8
68	770	Alabama	Tuscaloosa	Jagger	do	do	.68	25.20	61.72	12.40	13,473	11.8
54	686	do	Jefferson	Pratt	do	do	.90	22.80	49.00	27.30	11,039	11.7
104	560	Kansas	Crawford	Weir-Pittsburg	do	do	1.53	26.97	39.95	31.55	9,454	11.6
72	387	Alberta, Canada			do	do	1.12	26.11	56.97	15.80	12,415	11.5
59	750	Alabama	Bibb	Thompson	do	do	1.35	29.23	39.19	30.23	9,785	11.4
100	869	Illinois	Sangamon	No. 5	do	Rib	3.37	35.83	43.87	16.93	10,759	11.4
105	992	do	Franklin	No. 6	do	Road	3.43	27.10	45.77	23.70	10,197	11.3
94	342	Iowa	Monroe	No. 2 or Buxton	do	Grab sample	4.84	30.21	29.35	35.60	7,198	11.0
67	437	New Mexico	Colfax	"Raton"	do	Road	2.00	32.00	38.80	27.20	10,226	10.9
106	841	Pennsylvania	Allegheny	Upper Freeport	do	Rib	1.45	27.43	41.49	29.63	9,938	10.8
44	780	Illinois	Franklin	No. 6	do	Road	1.98	26.37	47.50	24.15	10,415	10.7
77	930	West Virginia	Fayette	Fire Creek	Semibituminous	do	.78	19.60	64.25	15.37	13,122	10.6
72	393	Alberta, Canada			Bituminous	do	1.19	26.51	57.70	14.60	12,577	10.5
86	945	Pennsylvania	Cambria	Upper Kittanning	Semibituminous	do	1.31	19.07	63.70	15.92	12,560	10.4
107	989	Illinois	Franklin	No. 6	Bituminous	do	3.60	26.30	40.59	29.51	9,133	10.3
51	793	Pennsylvania	Allegheny	Pittsburgh	do	do	1.00	25.65	43.42	29.93	10,094	10.2

[a] Numbers correspond to those in Table 1.

Digitized by Google
Original from PRINCETON UNIVERSITY

Generated on 2024-09-28 16:17 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 2.—*Inflammability of road and rib dusts*—Continued.

Mine No.	Test No.	State.	County.	Coal bed.	Kind of coal.	Character of dust.	Proximate analysis.				B. t. u.	Inflammability.
							Moisture.	Volatile matter.	Fixed carbon.	Ash.		
							Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		*Lbs. per sq. inch.*
108	890	West Virginia	Fayette	Fire Creek	Semibituminous	Road	.67	17.88	61.62	19.83	12,382	9.9
54	655	Alabama	Jefferson	Pratt	Bituminous	Rib	1.35	22.70	48.82	27.13	10,514	9.7
109	823	West Virginia	Fayette	Sewell	do	do	1.03	22.22	67.97	8.78	13,849	9.7
105	991	Illinois	Franklin	No. 6	do	Road	2.94	21.64	33.84	41.58	7,715	9.6
106	842	Pennsylvania	Allegheny	Upper Freeport	Semibituminous	Rib	2.30	26.95	36.86	33.89	8,813	9.6
72	383	Alberta, Canada			Bituminous	Road	1.20	26.73	57.67	14.40	12,604	9.5
67	444	New Mexico	Colfax	"Blossburg"	do	do	1.40	27.60	30.30	40.70	8,428	9.5
45	994	Illinois	Montgomery	No. 6	do	do	4.68	25.90	25.62	43.80	6,806	8.7
77	933	West Virginia	Fayette	Fire Creek	Semibituminous	do	.76	17.96	61.43	19.85	12,271	8.0
79	419	do	Raleigh	Beckley	do	Grab sample	1.10	17.78	73.79	7.33		7.9
60	548	Pennsylvania	Allegheny	Pittsburgh	Bituminous	Road	1.50	23.73	39.77	35.00	8,995	7.8
110	836	Indiana	Vigo	No. 5	do	do	2.61	26.07	23.13	48.19	6,615	7.1
79	413	West Virginia	Raleigh	Beckley	Semibituminous	do	1.30	16.85	65.87	15.98		7.1
59	679	Alabama	Bibb	Thompson	Bituminous	Rib	1.25	19.33	38.62	40.80	7,956	6.8
96	430	Kentucky	Henderson	No. 9	do	do	7.65	26.60	29.92	35.83	6,998	6.3
60	498	Pennsylvania	Allegheny	Pittsburgh	do	Road	1.02	25.56	38.01	35.41		6.2
67	446	New Mexico	Colfax	"Raton"	do	do	1.70	23.00	24.75	50.55	6,727	6.2
77	960	West Virginia	Fayette	Fire Creek	Semibituminous	do	1.10	15.65	52.40	30.85	10,444	6.2
111	826	Illinois	Peoria	No. 5	Bituminous	do	2.45	23.90	24.73	48.92		6.1
109	822	West Virginia	Fayette	Sewell	do	Rib	1.30	15.88	73.32	9.50	13,500	4.8
86	943	Pennsylvania	Cambria	Upper Kittanning	Semibituminous	Road	1.08	15.02	74.78	9.12	13,741	3.8
77	917	West Virginia	Fayette	Fire Creek	do	Rib	.95	15.83	58.42	24.80	11,259	2.6
79	404	do	Raleigh	Beckley	do	Road	1.35	15.33	48.99	34.33		2.3
6	559	Wyoming	Sheridan	Monarch	Subbituminous	Rib	5.25	23.25	13.20	58.30	4,158	1.5
112	901	West Virginia	McDowell	War Creek	Semibituminous	Rib and gob	1.43	14.72	61.99	21.86	11,527	1.1
113	a662	British Columbia		"No. 0"	Anthracite	Road	.40	9.95	78.55	11.10	13,720	0.9
100	a921	Illinois	Sangamon	No. 5	Bituminous	do	4.71	21.72	20.90	52.67	5,390	0.6

a 300 mg. used for test.

Digitized by Google
Original from PRINCETON UNIVERSITY

These tests have shown the desirability of making screen tests of the road-dust samples received for inflammability tests, so as to obtain more accurate information regarding the quantity of shale dust needed to prevent either ignition or propagation than is afforded by laboratory tests with only the finely pulverized dust. The results of the laboratory tests of road dusts given in Table 2 may, therefore, be somewhat in error, for the relative inflammability of the dust as received may be less than that given by the finely pulverized dust in the laboratory. In some cases where the pressure obtained indicated that the dust could be ignited or might propagate flame, ignition or propagation might be impossible on account of the coarseness of the dust. However, any error due to this cause is on the side of safety, as the laboratory test indicates an inflammability greater than may exist, and therefore recommendations based on such tests would require more shale than necessary to prevent ignition or propagation.

A somewhat similar situation has developed with reference to coals of high moisture content. Laboratory tests of air-dried samples of a coal normally having about 10 per cent moisture gave limits somewhat higher than those found in the mine tests. But here also the error is on the safe side. With coals having a moisture content above 10 per cent the results may differ so much as to reduce considerably the value of the laboratory determination. It may be that this inaccuracy can be eliminated by tests of samples which have had opportunity after being pulverized to recover their original moisture content.

SUMMARY.

A laboratory method for determining the inflammability of coal dust has been developed that is more sensitive and capable of much greater accuracy than the methods previously described. With the apparatus described inflammability determinations have been made on a large number of samples of coal dust from the various coal fields of the United States.

By establishing a relation between the results of laboratory tests and those of tests under actual mining conditions it has been found possible to determine from laboratory tests whether dusts are capable of giving rise to explosions in the mine.

The inflammability of mixtures of coal dust and rock dust has been studied, and it is possible to predict from laboratory tests the percentage of rock dust that will render each coal dust incapable of propagating an explosion.

A convenient means has been provided for determining the effect on the inflammability of a dust of small percentages of combustible gas in the atmosphere in which the dust is suspended. By means of this modification the effect of such small percentages of gas with several typical coals and coal-shale mixtures has been studied.

Generated on 2024-09-28 16:13 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

PUBLICATIONS ON COAL MINING.

A limited supply of the following publications of the Bureau of Mines has been printed and is available for free distribution until the edition is exhausted. Requests for all publications can not be granted, and to insure equitable distribution applicants are requested to limit their selection to publications that may be of especial interest to them. Requests for publications should be addressed to the Director, Bureau of Mines.

The Bureau of Mines issues a list showing all its publications available for free distribution as well as those obtainable only from the Superintendent of Documents, Government Printing Office, on payment of the price of printing. Interested persons should apply to the Director, Bureau of Mines, for a copy of the latest list.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

BULLETIN 17. A primer on explosives for coal miners, by C. E. Munroe and Clarence Hall. 61 pp., 10 pls., 12 figs.

BULLETIN 20. The explosibility of coal dust, by G. S. Rice, with chapters by J. C. W. Frazer, Axel Larsen, Frank Haas, and Carl Scholz. 204 pp., 14 pls., 28 figs.

BULLETIN 45. Sand available for filling mine workings in the northern anthracite coal basin of Pennsylvania, by N. H. Darton. 1912. 33 pp., 8 pls., 5 figs.

BULLETIN 46. An investigation of explosion-proof mine motors, by H. H. Clark. 1912. 44 pp., 6 pls., 14 figs.

BULLETIN 48. The selection of explosives used in engineering and mining operations, by Clarence Hall and S. P. Howell. 1914. 50 pp., 3 pls., 7 figs.

BULLETIN 50. A laboratory study of the inflammability of coal dust, by J. C. W. Frazer, E. J. Hoffman, and L. A. Scholl, jr. 1913. 60 pp., 95 figs.

BULLETIN 52. Ignition of mine gases by the filaments of incandescent electric lamps, by H. H. Clark and L. C. Ilsley. 1913. 31 pp., 6 pls., 2 figs.

BULLETIN 56. First series of coal-dust explosion tests in the experimental mine, by G. S. Rice, L. M. Jones, J. K. Clement, and W. L. Egy. 1913. 115 pp., 12 pls., 28 figs.

BULLETIN 57. Safety and efficiency in mine tunneling, by D. W. Brunton and J. A. Davis. 1914. 271 pp., 6 pls., 45 figs.

BULLETIN 60. Hydraulic mine filling, its use in the Pennsylvania anthracite fields, a preliminary report, by Charles Enzian. 1913. 77 pp., 3 pls., 12 figs.

BULLETIN 62. National mine rescue and first-aid conference, Pittsburgh, Pa., September 23–26, 1912, by H. M. Wilson. 1913. 74 pp.

BULLETIN 68. Electric switches for use in gaseous mines, by H. H. Clark and R. W. Crocker. 1913. 40 pp., 6 pls.

BULLETIN 74. Gasoline mine locomotives in relation to safety and health, by O. P. Hood and R. H. Kudlich, with a chapter on methods of analyzing exhaust gases, by G. A. Burrell. 1915. 84 pp., 3 pls., 27 figs.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

BULLETIN 90. Abstracts of current decisions on mines and mining, December, 1913, to September, 1914, by J. W. Thompson. 1915. 176 pp.

BULLETIN 93. Miners' nystagmus, by F. L. Hoffman. 1916. 67 pp.

BULLETIN 99. Mine-ventilation stoppings, with especial reference to coal mines in Illinois, by R. Y. Williams. 1915. 30 pp., 4 pls., 4 figs.

BULLETIN 101. Abstracts of current decisions on mines and mining, October, 1914, to April, 1915, by J. W. Thompson. 1915. 138 pp.

BULLETIN 102. The inflammability of Illinois coal dusts, by J. K. Clement and L. A. Scholl, jr. 1916. 74 pp., 5 pls., 22 figs.

BULLETIN 105. Black damp in mines, by G. A. Burrell, I. W. Robertson, and G. G. Oberfell. 1916. 92 pp.

BULLETIN 113. Abstracts of current decisions on mines and mining, reported from May to September, 1915, by J. W. Thompson. 1916. 124 pp.

BULLETIN 118. Abstracts of current decisions on mines and mining, reported from October to December, 1915, by J. W. Thompson. 1916. 74 pp.

BULLETIN 126. Abstracts of current decisions on mines and mining, reported from January to April, 1916, by J. W. Thompson. 1916. 90 pp.

BULLETIN 143. Abstracts of current decisions on mines and mining, reported from May to August, 1916, by J. W. Thompson. 1917. 72 pp.

TECHNICAL PAPER 2. The escape of gas from coal, by H. C. Porter and F. K. Ovitz. 1911. 14 pp., 1 fig.

TECHNICAL PAPER 11. The use of mice and birds for detecting carbon monoxide after mine fires and explosions, by G. A. Burrell. 1912. 15 pp.

TECHNICAL PAPER 13. Gas analysis as an aid in fighting mine fires, by G. A. Burrell and F. M. Seibert. 1912. 16 pp., 1 fig.

TECHNICAL PAPER 19. The factor of safety in mine electric installations, by H. H. Clark. 1912. 14 pp.

TECHNICAL PAPER 21. The prevention of mine explosions, report and recommendations, by Victor Watteyne, Carl Meissner, and Arthur Desborough. 12 pp.

TECHNICAL PAPER 23. Ignition of mine gas by minature electric lamps with tungsten filaments, by H. H. Clark. 1912. 5 pp.

TECHNICAL PAPER 28. Ignition of mine gas by standard incandescent lamps, by H. H. Clark. 1912. 6 pp.

TECHNICAL PAPER 43. The effect of inert gases on inflammable gaseous mixtures, by J. K. Clement. 1913. 24 pp., 1 pl., 8 figs.

TECHNICAL PAPER 44. Safety electric switches for mines, by H. H. Clark. 1913. 8 pp.

TECHNICAL PAPER 62. Relative effects of carbon monoxide on small animals, by G. A. Burrell, F. M. Seibert, and I. W. Robertson. 1914. 23 pp.

TECHNICAL PAPER 67. Mine signboards, by Edwin Higgins and Edward Steidle. 1913. 15 pp., 1 pl., 4 figs.

TECHNICAL PAPER 75. Permissible electric lamps for miners, by H. H. Clark. 1914. 21 pp., 3 figs.

TECHNICAL PAPER 82. Oxygen mine rescue apparatus and physiological effects on users, by Yandell Henderson and J. W. Paul. 1917. 102 pp. 5 pls., 6 figs.

TECHNICAL PAPER 84. Methods of preventing and limiting explosions in coal mines, by G. S. Rice and L. M. Jones. 1915. 50 pp., 14 pls., 5 figs.

TECHNICAL PAPER 100. Permissible explosives prior to March 1, 1915, by S. P. Howell. 1915. 16 pp.

TECHNICAL PAPER 103. Organizing and conducting safety work in mines, by H. M. Wilson and J. R. Fleming. 1917. 57 pp., 35 figs.

TECHNICAL PAPER 108. Shot firing in coal mines by electricity controlled from the outside, by H. H. Clark, N. V. Breth, and C. M. Means. 1915. 36 pp.

Generated on 2024-09-28 16:14 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

TECHNICAL PAPER 112. The explosibility of acetylene, by G. A. Burrell and G. G. Oberfell. 1915. 15 pp.

TECHNICAL PAPER 119. The limits of inflammability of mixtures of methane and air, by G. A. Burrell and G. G. Oberfell. 1915. 30 pp., 4 figs.

TECHNICAL PAPER 121. Effects of temperature and pressure on the explosibility of methane-air mixtures, by G. A. Burrell and I. W. Robertson. 1916. 14 pp., 3 figs.

TECHNICAL PAPER 122. Effects of oxygen deficiency on small animals and on men, by G. A. Burrell and G. G. Oberfell. 1915. 12 pp.

TECHNICAL PAPER 132. Underground latrines for mines, by J. H. White. 1916. 23 pp., 2 pls., 7 figs.

TECHNICAL PAPER 134. Explosibility of gases from mine fires, by G. A. Burrell and G. G. Oberfell. 1916. 31 pp., 1 fig.

TECHNICAL PAPER 138. Suggested safety rules for installing and using electrical equipment in bituminous coal mines, by H. H. Clark and C. M. Means. 1917. 36 pp.

MINERS' CIRCULAR 5. Electrical accidents in mines, their causes and prevention, by H. H. Clark, W. D. Roberts, L. C. Ilsley, and H. F. Randolph. 1911. 10 pp., 3 pls.

MINERS' CIRCULAR 7. Use and misuse of explosives in coal mining, by J. J. Rutledge, with a preface by J. A. Holmes. 1913. 52 pp., 8 figs.

MINERS' CIRCULAR 9. Accidents from falls of roof and coal, by G. S. Rice. 1912. 16 pp.

MINERS' CIRCULAR 10. Mine fires and how to fight them, by J. W. Paul. 1912. 14 pp.

MINERS' CIRCULAR 11. Accidents from mine cars and locomotives, by L. M. Jones. 1902. 16 pp.

MINERS' CIRCULAR 12. Use and care of miners' safety lamps, by J. W. Paul. 1913. 16 pp., 4 figs.

MINERS' CIRCULAR 13. Safety in tunneling, by D. W. Brunton and J. A. Davis. 1913. 19 pp.

MINERS' CIRCULAR 14. Gases found in coal mines, by G. A. Burrell and F. M. Seibert. 1913. 23 pp.

MINERS' CIRCULAR 16. Hints on coal-mine ventilation, by J. J. Rutledge. 1914. 22 pp.

MINER' CIRCULAR 18. Notes on miners' carbide lamps, by J. W. Paul. 1915. 11 pp.

MINERS' CIRCULAR 21. What a miner can do to prevent explosions of gas and of coal dust, by G. S. Rice. 1915. 24 pp.

MINERS' CIRCULAR 23. Elementary first aid for the miner, by W. A. Lynott and D. Harrington. 1916. 24 pp., 19 figs.

Rescue and recovery operations in mines after fires and explosions, by J. W. Paul and H. M. Wolflin. 1916. 109 pp.

PUBLICATIONS THAT MAY BE OBTAINED ONLY THROUGH THE SUPERINTENDENT OF DOCUMENTS.

BULLETIN 10. The use of permissible explosives, by J. J. Rutledge and Clarence Hall. 1912. 34 pp., 5 pls., 4 figs. 10 cents.

BULLETIN 25. Mining conditions under the city of Scranton, Pa., report and maps, by William Griffith and E. T. Conner, with a preface by J. A. Holmes and a chapter by N. H. Darton. 1912. 89 pp., 29 pls. 50 cents.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY

BULLETIN 26. Notes on explosive mine gases and dusts, with especial reference to explosions in the Monongah, Darr, and Naomi coal mines, by R. T. Chamberlin. 383 pp., 1 fig. 10 cents.

BULLETIN 42. The sampling and examination of mine gases and natural gas, by G. A. Burrell and F. M. Seibert. 1913. 116 pp., 2 pls., 23 figs. 20 cents.

BULLETIN 44. First national mine-safety demonstration, Pittsburgh, Pa., October 30 and 31, 1911, by H. M. Wilson and A. H. Fay, with a chapter on the explosion at the experimental mine, by G. S. Rice. 1912. 75 pp., 8 pls., 4 figs. 15 cents.

BULLETIN 61. Abstracts of current decisions on mines and mining. October, 1912, to March, 1913, by J. W. Thompson. 1913. 82 pp. 10 cents.

BULLETIN 72. Occurrence of explosive gases in coal mines, by N. H. Darton. 1915. 248 pp., 7 pls., 33 figs. 35 cents.

BULLETIN 79. Abstracts of current decisions on mines and mining, March to December, 1913, by J. W. Thompson. 1914. 140 pp. 20 cents.

BULLETIN 82. International conference of mine experiment stations, Pittsburgh, Pa., September 14–21, 1912, compiled by G. S. Rice. 1914. 99 pp. 15 cents.

BULLETIN 83. The humidity of mine air, with especial reference to coal mines in Illinois, by R. Y. Williams. 1914. 69 pp., 2 pls., 7 figs. 10 cents.

BULLETIN 94. United States mining statutes annotated, by J. W. Thompson. 1915. 1772 pp. In two parts, not sold separately. Cloth, $2.50 per set; paper, $2.00.

TECHNICAL PAPER 14. Apparatus for gas-analysis laboratories at coal mines, by G. A. Burrell and F. M Seibert. 1913. 24 pp., 7 figs. 5 cents.

TECHNICAL PAPER 17. The effect of stemming on the efficiency of explosives, by W. O. Snelling and Clarence Hall. 1912. 20 pp., 1 fig. 5 cents.

TECHNICAL PAPER 24. Mine fires, a preliminary study, by G. S. Rice. 1912. 51 pp., 1 fig. 5 cents.

TECHNICAL PAPER 29. Training with mine-rescue breathing apparatus, by J. W. Paul. 1912. 16 pp. 5 cents.

TECHNICAL PAPER 39. The inflammable gases in mine air, by G. A. Burrell and F. M. Seibert. 1913. 24 pp., 2 figs. 5 cents.

TECHNICAL PAPER 47. Portable electric mine lamps, by H. H. Clark. 1913. 8 pp. 5 cents.

TECHNICAL PAPER 56. Notes on the prevention of gas and dust explosions in coal mines, by G. S. Rice. 1913. 24 pp. 5 cents.

TECHNICAL PAPER 77. Report of the Committee on Resuscitation from Mine Gases, by W. B. Cannon, G. W. Crile, Joseph Erlanger, Yandell Henderson, and S. J. Meltzer. 1914. 35 pp., 4 figs. 5 cents.

TECHNICAL PAPER 101. Permissible explosion-proof electric motors for mines; conditions and requirements for test and approval, by H. H. Clark. 1915. 14 pp., 2 pls., 1 fig. 5 cents.

MINERS' CIRCULAR 4. The use and care of mine-rescue breathing apparatus, by J. W. Paul. 1911. 24 pp., 5 figs. 5 cents.

MINERS' CIRCULAR 15. Rules for mine-rescue and first-aid field contests, by J. W. Paul. 1913. 12 pp. 5 cents.

Generated on 2024-09-28 16:15 GMT / https://hdl.handle.net/2027/njp.32101054990401
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from PRINCETON UNIVERSITY